Soil moisture measurements and microwave remote sensing in West Africa

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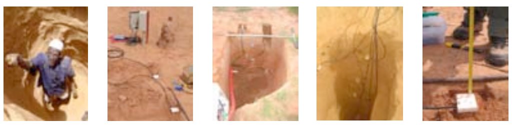
One of the objectives of AMMA (African Monsoon Multidisciplinary Analysis) project is to address the role of soil moisture on monsoon dynamics and variability. The poster presents the soil moisture measurement strategy (about 130 soil moisture sensors were installed since 2005) and a few results and applications of the soil moisture network compared with some active (ENVISAT-ASAR, ERS-Scat) and passive (AMSR-E) microwave measurements over West Africa.

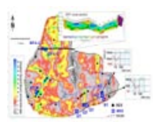
Soil moisture measurements in West Africa

- 120 CS615/616 (Campbell) between 5 cm and 230 cm depth
- 10 Theta Probes
- 30 soil moisture profiles



Hydrological measurements

- ~1000 daily reading raingauge stations
- 200 daily raingauges since 1960 in Sahel
- 150 automatic raingauge stations (3 sites)
- ~30 limnimeters (3 sites)



Electrical resistivity measurements in Benin

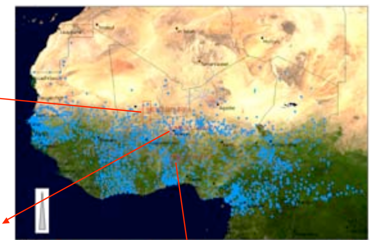
Fluxes measurements

- 4+4+6 fluxes stations
- 2+2+3 CO2 flux stations

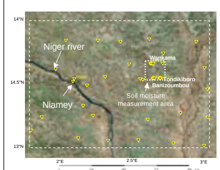
Flux towes in Niger

The three super sites of AMMA

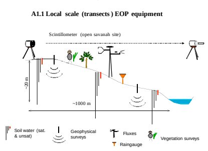
In Mali, 9 sites were instrumented with soil moisture stations in a North-South direction



Raingauge network in West Africa and location of the three super-sites of the AMMA programme (backgroung, SPOT-Vegetation)



In Niger, 3 sites were devoted to measure soil moisture under various soil and vegetation characteristics



In Benin, three sites were instrumented with soil moisture profiles following the topographic slope

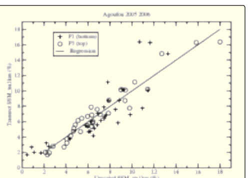
Evaluation of satellite products and hydrological applications using microwave sensors (AMSR-E, ENVISAT-ASAR, ERS-Scat, Metop-Ascat)

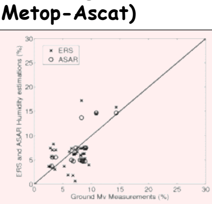
Spatial stability of soil moisture ground measurements

Surface soil moisture estimated at the 1km scale from transect measurements (vertical axis) and from the local Agoufou top of hillslope station measurements to which was applied the following up-scaling relation (horizontal axis).

$SSM_{tra1km} = -0.68855 + 1.7561xSSM_{staloc}$

(de Rosnay et al., *J. of Hydrol.*, submitted)



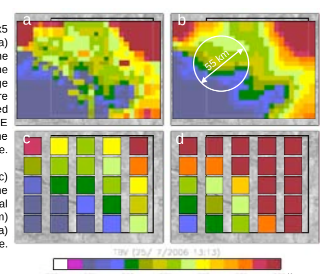


Inter-comparison between ground data and ERS (x) and ASAR (o) surface soil moisture products for the Niger (Zribi et al., *J. of Hydrol.*, submitted)

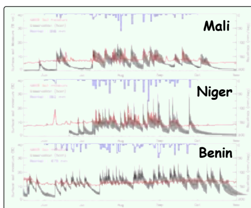
Simulated vs. observed microwave TB over a 120x100 km² region (Niger)

High resolution (5x5 km²) microwave TB (a) are simulated over the Niger site using the dense raingage stations and are compared to observed (25x20 km²) AMSR-E TB (d) for the 25/07/2006 13:13 date.

Step (b) and (c) describe how the AMSR-E sensor (real footprint of 55 km) would observed the (a) scene.

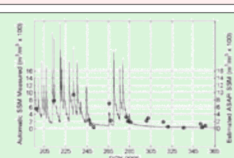


(Pellarin et al., *J. of Hydrol.*, submitted)



AMSR-E soil moisture product - AMSR-E/Aqua Daily L3 Surface Soil Moisture, Interpretive Parms, & QC EASE-Grids (AE_LAND3) - evaluation over three sites in Mali, Niger and Benin.

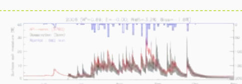
Temporal variation of automatic SSM measurements and satellite-derived SSM using Envisat-ASAR data acquired at low incidence angles (<30°) for the Agoufou site (Baup et al., *IEEE TGRS*)



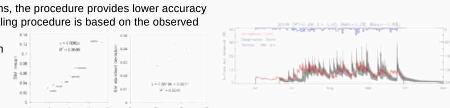
High resolution soil moisture mapping based on a rain product, a simple Antecedent Precipitation Index (API) model and assimilation of AMSR-E measurements

Step 1: The simple API model is able to provide accurate soil moisture estimates over pixels where in-situ measurements are available. A rescaling procedure is needed following:

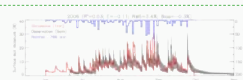
$$API^{+} = API^{-}e^{-30/\tau} + P \quad \text{and} \quad API^{norm} = \left(API - \mu^{API}\right)\left(\sigma^{\theta}/\sigma^{API}\right) + \mu^{\theta}$$

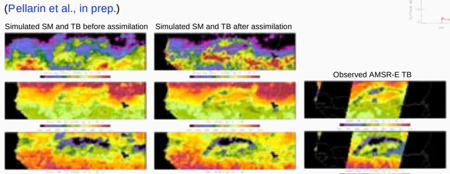


Step 2: Using satellite rain estimations, the procedure provides lower accuracy of soil moisture estimates. The rescaling procedure is based on the observed relationship between the mean and standard deviation of the satellite rain estimations and the in-situ soil moisture of six plot scale measurements



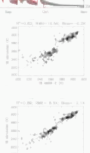
Step 3: C-band microwave emission of the soils are simulated and an assimilation technique of the AMSR-E measurements is done by adapting (x0, x0.25, x0.5, x1, x2, x5) the rainfall estimates to match the TB measurements. (Pellarin et al., in prep.)





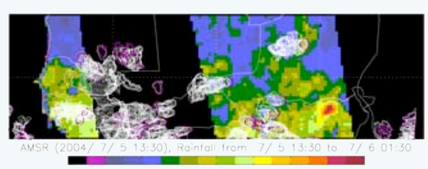
Observed and simulated TB before assimilation

Observed and simulated TB after assimilation



Surface boundary condition role in initiation and maintenance of the West-African Monsoon system

Figure below presents soil moisture mapping provided by AMSR/AQUA associated with convective cells tracking provided by MSG. This figure seems to highlight privileged zones of beginning convection and soil moisture seems to affect locally the system trajectories. Several authors have observed opposite behaviour in West Africa. Some precipitation systems were attracted by wet areas whereas some other systems seemed to be repulsed by wet areas (Pellarin et al. in prep.)



SMOS-AMMA Cal-Val site

The AMMA soil moisture network will be used for the SMOS Cal-Val procedure in 2009-2010. The main interest is related to the strong meridional gradient of vegetation composed with forest areas in Benin, to desert areas in North Mali.

The Cal-Val procedure will also benefit from land surface model developments as well as assimilation techniques experiments conducted during the AMMA programme.

SMOS Satellite (ESA)

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